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APPLICATION NUMBER: *60/467,798*
FILING DATE: *May 02, 2003*
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

Express Mail Label No. EV249513584 US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Jaime Arturo	Valenzuela	Alhambra, California USA

☐ *Additional inventors are being named on the _____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

Digital Reproduction of Variable Density Film Soundtracks

CORRESPONDENCE ADDRESS

Direct all correspondence to:

☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*

OR *Type Customer Number here*

☒ Firm *or* Individual Name	JOSEPH S. TRIPOLI, THOMSON LICENSING INC.
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Country	USA · Telephone: 609-734-6834 · Fax: 609-734-6888

ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 13 ☐ CD(s), Number

☒ Drawing(s) *Number of Sheets* 4 ☐ Other (specify)

☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT *(check one)*

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 07-0832

FILING FEE AMOUNT ($) 160

☐ Payment by credit card. Form PTO-2038 is attached.

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: _____.

Respectfully submitted,
SIGNATURE Francis A. Davenport

Date 5/02/03

REGISTRATION NO. *(if appropriate)* 36,316

TYPED or PRINTED NAME FRANCIS A. DAVENPORT

Docket Number: PU030134

TELEPHONE 609 734-6805

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

FEE TRANSMITTAL for FY 2003

Patent fees are subject to annual revision.

Complete if Known	
Application Number	N/A
Filing Date	HEREWITH
First Named Inventor	Jaime Arturo Valenzuela
Examiner Name	N/A
Group / Art Unit	N/A
Attorney Docket No.	PU030134

TOTAL AMOUNT OF PAYMENT ($) 160

METHOD OF PAYMENT (check one)

1. ☒ The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number: 07-0832

Deposit Account Name: THOMSON multimedia Licensing Inc.

☒ Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

☐ Applicant claims small entity status. See 37 CFR 1.27

2. ☐ Payment Enclosed:

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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	740	201	370	Utility filing fee	
106	330	206	165	Design filing fee	
107	510	207	255	Plant filing fee	
108	740	208	370	Reissue filing fee	
114	160	214	80	Provisional filing fee	160

SUBTOTAL (1) ($) 160

2. EXTRA CLAIM FEES

			Extra Claims		Fee from below		Fee Paid
Total Claims		-20 ** =	0	X		=	0
Independent Claims		-3 ** =	0	X		=	0
Multiple Dependent				X		=	0

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	84	202	42	Independent claims in excess of 3
104	280	204	140	Multiple dependent claim, if not paid
109	84	209	42	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent

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FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet.	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	400	216	200	Extension for reply within second month	
117	920	217	460	Extension for reply within third month	
118	1,440	218	720	Extension for reply within fourth month	
128	1,960	228	980	Extension for reply within fifth month	
119	320	219	160	Notice of Appeal	
120	320	220	160	Filing a brief in support of an appeal	
121	280	221	140	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive – unavoidable	
141	1,280	241	640	Petition to revive – unintentional	
142	1,280	242	640	Utility issue fee (or reissue)	
143	460	243	230	Design issue fee	
144	620	244	310	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Processing fee under 37 CFR 1.17 (q)	
126	180	126	180	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	740	246	370	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	740	249	370	For each additional invention to be examined (37 CFR § 1.129(b))	
179	740	279	370	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	

Other fee (specify) ____

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0

SUBMITTED BY

Complete (*if applicable*)

Name (Print/Type)	Francis A. Davenport	Registration No. Attorney/Agent)	36,316	Telephone	609-734-6805
Signature	Francis A. Davenport			Date	May 2, 2003

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Digital Reproduction of Variable Density Film Soundtracks

This invention relates to the reproduction of optically recorded analog sound tracks and in particular to the restoration of recorded signal quality in variable density recordings.

Background:

Optical recording is most common format employed for analog motion picture sound tracks. This analog format uses a variable area method where illumination from a calibrated light source is passed through a shutter modulated with the audio signal. The shutter opens in proportion to the intensity or level of the audio signal and results in the illumination beam from the light source being modulated in width. This varying width illumination is directed to expose a monochromatic photographic film which when processed, for example, results in a black audio waveform envelope surrounded at the waveform extremities by a substantially clear or colored film base material. In this way the instantaneous audio signal amplitude is represented by the width of the exposed and developed film.

A second method can be employed for analog motion picture soundtracks where the audio signal causes the total width of the photographic audio track to be variably exposed. In this method, termed variable density, the exposure of the complete track width is varied in accordance with the amplitude of the audio signal to produce a track which varies in optical transmission, for example, between substantially a clear or colored base film material and low transmission or high density areas of exposed and developed photographic material. Thus the instantaneous audio signal amplitude is represented by a variation in the transmission of illumination though the exposed and developed film track width. This recording method is characterized by a poor, low signal to noise ratio and signal amplitude distortion resulting from exposing the film into areas of the transfer characteristic that exhibit non-linearity. In addition, inter-modulation distortion is produced as sections of the film track immediately adjacent to the intended exposure areas are effected by both light diffraction around the recording slit and scattering within the film emulsion. FIGURE 1 depicts in greatly simplified form an arrangement for recording a variable density analog audio sound track.

Hence with either variable density or variable area recording methods the

audio modulation (sound) can be recovered by suitably gathering, for example by means of a photo detector (100 of FIGURE 3), illumination transmitted through the sound track area.

These analog film sound recording techniques are subject to imperfections, physical damage and contamination during recording, printing and subsequent handling. Since these recording techniques use photographic film, the amount of light used in recording (Density) and the exposure time (Exposure) are critical parameters. The correct density for recording can be determined by a series of tests to determine the highest and lowest possible densities that fall in the linear portions of the transfer characteristic of the film.

Sound recording film is generally only sensitive blue illumination and employs a gray anti-halation dye to substantially reduce or eliminate halation effects. Halation can result from reflections from the back of the film base causing a secondary, unwanted exposure of the emulsion. Typically a variable area track has a gamma between 0.5 and 1.6.

The frequency response of the variable density recording method is determined by various parameters, for example, the width of the slit used to pass the modulated light through, the exposure of the film, and the modulation transfer function MTF of the film which is directly related to light diffusion. The higher the exposure time the lower the frequency bandwidth of the recording.

Optimum density presents a compromise between signal to noise ratio and inter-modulation distortion and non-linear exposures. An optimum density can be determined by test exposures to find an acceptably low value for inter-modulation distortion resulting from image spreading.

In addition to non-linear densities and inter-modulation distortion other imperfections can result, for example the density of the exposed or unexposed areas can vary randomly or in sections across or along the sound track area. During audio track playback such density variations can directly translate into spurious noise components interspersed with the wanted audio signal.

A further source of audio track degradation relates to mechanical imperfections variously imparted to the film and or incurred during reproduction. One such deficiency causes the film, or tracks thereon, to weave or move laterally with respect to a fixed transducer. Film weave can result in various forms of imperfection such as amplitude and phase modulation of the reproduced audio

signal.

Analog optical recording methods are inherently susceptible to physical damage and contamination during handling. For example, dirt or dust can introduce transient, random noise events. Similarly scratches in either the exposed or unexposed areas can alter the optical transmission properties of the sound track and cause severe transient noise spikes. Furthermore other physical or mechanical consequences, such as the film perforation, improper film path lacing or related film damage can introduce unwanted cyclical repetitive effects into the soundtrack. These cyclical variations can introduce spurious illumination and give rise to a low frequency buzz, for example having an approximately 96 Hz rectangular pulse waveform, rich in harmonics and interspersed with the wanted audio signal. Similarly picture area light leakage into the sound track area can also cause image related audio degradation.

Conventional analog sound track readers only reproduce the changes in light transmitted through the film together with all its imperfections, such readers offer no correction of the variable density track anomalies and deficiencies discussed previously. European patent EP 1091573 teaches compensations for the effects of variations in density or shading due to errors in printing and noise generated by the CCD imager scanning the track. However, the patent fails to address the effects of inter-modulation distortion, and in addition teaches the use of 8 bit signal quantization which yields an unacceptably low signal to noise ratio in the order of 49 dBs.

A German application DE 197 29 201 A1 discloses a telecine which scans optically recorded sound tracks. The disclosed apparatus scans the sound information signal and applies two-dimensional filtering to the output values. A further German application DE 197 33 528 A1 describes a system for stereo sound signals. An evaluation circuit is utilized to provide only the left or the right sound signal or the sum signal of both as a monophonic output signal.

Clearly an arrangement is needed that allows optically recorded analog audio sound tracks to be reproduced and processed to not only substantially eliminate the noted deficiencies but to enhance the quality of the reproduced audio signal.

Summary Of The Invention

In an inventive arrangement a variable density optical format analog soundtrack is restored by use of digital signal processing. An advantageous arrangement employs a CCD line array imager to scan and form an image of the variable density track for storage as a digital signal on a hard disk memory. The CCD signal is quantized with 12 bit resolution to obtain an acceptable signal to noise ratio of approximately 74 dB in the resulting audio signal. An audio signal is extracted from the stored soundtrack image by use of various of the following processing methods which are performed to eliminate unwanted noise and distortion.

1) Averaging pixel intensities over each scanned line.

2) Use of standard deviation in each line of scanned data to eliminate extraneous pixel values.

3) Creation of a look-up-table to correct data values derived from non-linear areas of film density transfer characteristic.

4) Statistical and regression analysis of the pixel intensities values to extend beyond non-linear areas of film density transfer characteristic.

5) Adaptive filtering to minimize effects of inter-modulation distortion.

In an inventive arrangement the optical soundtrack is scanned by a 2048 pixel line scan CCD imager. Light from a light source passes through the sound track area of the film and is imaged to substantially fill the width of the CCD. The varying density of the soundtrack recording results in a corresponding variation of light transmitted to the CCD. FIGURE 5 illustrate a scanned image of a variable density sound track. The output signal from the CCD is quantized with a 12 bit resolution and stored in a RAID array. The exposure time of the CCD imager is synchronized with the bi-phase drive signals that control the film transport and thereby provide an exposure rate of about 30,000 scans per second which yields a nominal bandwidth of 15 KHz in the resulting sound track signal.

1) To compensate for the effects of film grain or granularity, which result in unwanted signal amplitude variations or random noise, statistical processing methods are used. A first method processes the data signal to determine an average value of the film density during each line scan by summing all

the pixel values and dividing by 2048. This average or mean value represents a good approximation to the wanted audio amplitude while minimizing the effects of random noise.

2) A second advantageous processing arrangement consists of calculating the standard deviation of each pixel in each line scan and eliminating pixel values that deviate above a user defined threshold. After which the mean is calculated to obtain a noise reduced instantaneous amplitude.

3) A third advantageous processing arrangement employs "look up tables" to correct for exposures or density values that fall in the non-linear toe and the shoulder areas of the H & D curve shown in FIGURE 2. The look up tables are constructed using, for example a logarithmic or a cubic polynomial function to linearize the toe area (AB) of the characteristic with exponential and square law functions used to linearize the shoulder part (CD) of the film transfer law. The various correction laws are user selectable to enable comparative evaluation of the processed audio. In addition the user can select the range of pixel values (intensities) that will be subject to correction by the selectable look up tables. For example different tables with different correction laws can be chosen for the toe and shoulder regions of the transfer characteristic with the correction cut in point (pixel values) of the imaged signal from the RAID array selected by the user.

4) A fourth advantageous processing arrangement employs a regression analysis technique to linearize the response curves of the optical track. In this arrangement the function shape and the range of pixel intensities are not input by the user, but rather a computer performs a sampling of the overall dynamic range of the track and an estimate of the slope and intercept of the response is calculated. Having determined the equation or mathematical function that the range of pixel values represent, other points beyond the linear range of the film characteristic can be estimated and the overall dynamic range of the track can be extended or linearized. Other linear operations can be performed to this line such as shifting in the X and Y axis by user defined values.

5) The effects of inter-modulation distortion are manifest as an asymmetrical increase of amplitude peaks that is dependent both on frequency and exposure (sound amplitude). Track areas of low density are little affected by inter-modulation distortion. A filter function is formed to subtract a percentage of the

measured intensity of both preceding and succeeding scanned lines from any given line. Typically edge diffraction effects yield a sinusoidal drop in intensity thus an advantageous corrective function can be formed with data from adjacent line scans. The range of scanned lines that are to be used to set the coefficients of the filter should be user selectable with the optimum value determined by listening tests. The line scan rate has a great influence on this parameter since a grater number of samples will describe the track with greater accuracy.

In a further inventive arrangement an apparatus for the playback of an analog optical sound track comprises a transport means for transporting a film including an analog optical sound track. A scanning means generates an image signal of only the analog optical sound track. An alignment means aligns the scanning means such that the image signal of the analog optical sound track substantially fills a width of the scanning means. A processor processes the image signal to form an audio output signal.

In yet a further inventive method positional variation of an analog optical sound track on a film is eliminated. The method comprises the steps of transporting the film including a sound track with an audio representative envelope subject to positional variation. Forming a digital image of the sound track with said audio representative envelope and aligning the digital image of said sound track with an audio representative envelope and ensuring the positional variation of said sound track on the film and peaks of the audio representative envelope remain within the digital image. Processing the digital image to separate only the audio representative envelope and form therefrom an audio output signal.

Another inventive apparatus facilitates azimuth alignment of a scanning means during optical sound track playback. The apparatus comprises film transport for transporting a film including an analog optical sound track. A scanning means generates an image signal of only the analog optical sound track and is aligned such that an image signal of the analog optical sound track substantially fills a width of the scanning means. An azimuth aligning means positions the scanning means such that equal density values of the image of said analog optical sound track are displayed concurrently with substantially the same brightness.

Brief Description Of The Drawings

FIGURE 1 is a diagrammatic representation of an audio variable density soundtrack recording method.

FIGURE 2 shows a film density characteristic.

FIGURE 3 is a block diagram of an inventive arrangement for processing optically recorded analog audio sound tracks.

FIGURE 4 illustrates causes of inter-modulation distortion.

FIGURE 5 shows a scanned gray scale image of a variable density audio soundtrack subject to certain deficiencies.

FIGURE 6 illustrates a control panel used in accordance with the inventive arrangement of FIGURE 3.

FIGURES 7A and 7B are charts representing sequences associated with various inventive arrangements.

FIGURES 8A and 8B are diagrams representing a sound track envelope reproduced with an azimuth error in FIGURE 8A and corrected in FIGURE 8B.

Detailed Description

The block diagram of FIGURE 3 shows an inventive arrangement for reproducing and processing an optically recorded analog audio sound track. Typically a light source 10 is projected onto film 20 which includes an audio sound track 25, depicted in FIGURE 3 with an exaggerated width dimension. The audio signal may be represented as suggested in track 25 by means of a variable density recording method. In a conventional film sound reproducer light from source 10 is transmitted through film 20 and track 25 and emerges with intensity varying in accordance with the method employed for exposing the sound track. However, the resulting varying intensity transmitted light is gathered by a photo sensor such as a photocell or solid-state photo detector. The photo sensor usually generates a current or voltage in accordance with the intensity of the transmitted light. An analog audio output signal results from the photo sensor and this is generally amplified and often processed to alter the frequency content to improve or mitigate deficiencies in the acoustic properties of the recorded track. However, such frequency response manipulation is generally incapable of remedying the deficiencies without adversely effecting the wanted audio content.

In the inventive arrangement shown in FIGURE 3, light from source 10 is guided by a fiber optic means (not illustrated) to form a projected beam of light for illuminating sound track 25. The light is modulated in intensity by the variable

density sound track and is collected by optical group 75. Optical group 75 includes a lens assembly, extension tube and bellows which are arranged to form an image of the complete sound track width across the width of a CCD line array sensor 110 which forms part of camera 100. Camera 100, for example a Aviiva type M2-CL, is controlled by frame grabber 200, for example, Matrox Meteor II CL digital board which synchronizes the image capture and outputting of an 12 bit digital signal representing the line scanned image of sound track 25 as the film moves continuously through the projected beam of light. The CCD line array sensor 110 has 2048 pixels and provides a parallel digital output signal 120, quantized to 12 bits and capable of operating with a pixel rate in the order of 60 MHz.

The digital image signal 120 represents 2048 successive measurements across the width of the sound track, which are captured as a 12 bit gray scale signal representing the instantaneous optical transmission of the sound track. This continuos succession of track width images or transmission / density measurements is stored by an exemplary RAID system 300 as a continuous digital image of the optical track.

An operating system can be resident in controller 400 or as depicted by block 405 which provides the user with a visual menu and control panel presentation on display 500. Controller 400 can a personal computer or can be implemented as a custom processor integrated circuit. However, the computer controller must support the high transfer rates associated with the camera data and requires at least 512 MB of RAM together with an Ultra SCSI 160 or fiber channel interface that can sustain the high transfer rates. In addition a dual processor computer can allow parallel processing which can increase both processing speed and performance.

Camera 100 has a line array CCD sensor with 2048 pixels and provides a 12 bit parallel digital output signal, 120, in accordance with CameraLink or RS 622 output signal formats. The use of a 2048 pixel line array sensor quantized to 12bit resolution provides an adequate signal to quantizing noise ratio of about 74 dB and resolution sufficient to capture the soundtrack envelope image without significant frequency response distortion. In addition the camera can be controlled by a frame grabber 200, which in addition provides synchronization to NTSC or HD television sync pulses via sync interface 250, and also permits an output data rate sufficient to capture sound track images at normal operating speed of nominally 24 fps.

Thus under control of frame grabber 200 and responsive to user control from

display and keyboard 600 the digital image is transmitted via a frame capture card 200 for storage on a hard disk memory array 300. For example the scanning rates employed in this advantageous arrangement result in an exemplary file size in the order of 5 giga bytes per minute and this bitstream is supplied for storage by a striped raid system 300 which facilitates storage of the large sound track image video file while providing rapid transfer rates.

The optical system includes a bellows extension tube and lens 75 which are accurately adjusted to image the standardized recorded track positions, however manual adjustments are provided to permit both focusing, exposure and image size adjustment or zoom control to allow the recorded film area to substantially fill the maximum sensor width with a small area of the soundtrack. The camera mounting system also facilitates both lateral and azimuth adjustments. Lateral adjustment L allows laterally mis-positioned tracks to be imaged, for example to eliminate sprocket or perforation generated buzz or picture related light spill. Furthermore in severe situations where lateral image adjustment fails to eliminate audible sprocket hole or perforation noise, or picture spill, the camera and lens can be adjusted to substantially fill the sensor width with a part of the recorded envelope positioned to avoid the offending illuminating noise source.

The selection of lens and optical system requirements are determined largely by the 35 mm audio optical track width and the width of the imager array. A 35 mm optical track has a standardized width of 2.13 mm, and the approximate length of the imager is about 20.48 mm based on a pixel size of 10 microns. Thus to enable the maximum width of a 35 mm sound track to fill the imager width requires an image magnification of about 10:1. Similarly for a 16 mm track having a width of 1.83 mm, in order to fill the sensor width requires the addition of a 56 mm extension tube or bellows.

In addition to the imaging considerations, the desired bandwidth of the processed audio signal must be considered. For example, if a reproduced audio bandwidth of 15 kHz is required, a sampling or image scanning rate of 30 kHz is needed. Thus with an exemplary sampling rate of 30 kHz, the camera will output 2048 pixels represented as 12 bit words for each image scan (audio track line scan) producing an output data rate of $3072*30*10^3$ or 92.1 mega bytes per second. Hence one minute of sound track requires approximately 5.53 gigabytes of storage. Such storage capacity requirements can be provided by an exemplary striped raid

system such as an Ultra Wide SCSI 160 drive.

The inventive film sound processing system is activated by keyboard 600 or mouse selection of an icon (Digital AIR II) which results in a Windows® like control screen arrangement presented on display screen 500, shown in detail in FIGURE 6. Various operating modes such as Preview, Record, Stop, Process and Export are presented as tool bar functions in a border area of the display. Initially the Preview mode can be selected from the tool bar functions which advantageously starts the sound track in motion and forms a sound track image on display screen 500. The gray scale image allows alignment of camera and optics to the recorded sound track. Optical group 75 is adjusted to ensure that the sound track image substantially fill the imager 110 width and to provide good image signal to noise ratio by ensuring proper CCD exposure which can differ between negative and positive prints and is also dependent on the type of film stock.

Advantageously the real time mage provides not only pictures of the sound track but also shows the presence of interference generating illumination emanating from the sprocket holes, or the picture area which can contaminate the sound track. This unwanted light ingress can be eliminated by using the on screen camera image to permit manipulation of optical group 75 to remove such unwanted audio contributions by carefully framing the soundtrack using picture zoom, pan and tilt as well as by manipulating the position of the light source with respect to the track. In addition the sound track image can be examined in detail by electronically magnifying selectable sections of the display envelope to permit camera azimuth alignment when reproducing a test film known as a buzz track. The magnified image is presented with an electronically cursor line which permits the evaluation of any perturbations or anomalies in the audio modulation envelope. With optimized azimuth alignment modulation peaks appear concurrently with substantially equal magnitude but opposite polarity. An optimum azimuth adjustment will produce concurrently maximized envelope peaks. Misalignment of azimuth between the camera and the sound track can result in an image which captures temporally different audio information, such as can occur with a stereo audio track pair. FIGURE 8A is diagram representing a sound track envelope reproduced with an exemplary and exaggerated azimuth error. Shown on the same time axis of FIGURE 8A is a processed or electronically cored image showing the temporal displacement resulting from an azimuth error between the camera imager

camera and the sound track. FIGURE 8B is the same envelope image as FIGURE 8A but reproduced without an azimuth error, and shown below on the same time axis is the electronically cored image which indicates that the envelope peaks have been scanned substantially concurrently and are of similar amplitudes.

An example of a Preview mode sound track image is shown in FIGURE 5. The gray scale picture in FIGURE 5 is of a duplicate negative sound track which includes various impairments. For example, on the right side of the sound track image unwanted illumination can be seen emanating from film perforations, a defect indicative of misalignment during duplication. In addition the sound track has a reduced width and shows lateral scratches probably incurred on the original negative. This advantageous real time sound track image permits rapid visual alignment of the camera and optics, rather that reliance on acoustically determined positioning. The scanning alignment sequence is depicted in the sequence chart of FIGURE 7A. The sound track image facilitates the substantial elimination of deficiencies resulting from prior misalignment. Following camera image optimization, framing, focus, exposure, etc., the Record mode is selected from the tool bar and the sound track is scanned, digitized as exemplary 12 bit words and stored in memory 300. Upon completing the scanning and storage steps the digital sound track image is processed by selecting the Processing mode from the tool bar.

The processing control panel shown in FIGURE 6 allows an operator to select and optimize film specific processing to be performed on the stored sound track image thereby obviating the potential for damaging the film material during repeated play back for optimization. Advantageous processing algorithms resident, for example in controller 400 or as depicted within block 410 are selected from the on screen menu via keyboard 600 and applied to data selectively retrieved from the stored digital image in system 300. The algorithms employed to remedy certain sound track deficiencies will be explained, however, the corrective processing sequence is depicted in the chart of FIGURE 7B. The processed and renovated digital signal is converted for outputting as digital audio signal 450 with selectable exemplary formats such as WAV, MOD, DAT, DA-88.

Having stored the complete soundtrack as a digital image the inventive Processing mode is selected from the on screen tool bar. The processing control panel shown in FIGURE 6 allows the operator to select and optimize processing

specific to the stored sound track image. For example film gauge is selectable, together with the film type, positive or negative and audio modulation method for example, unilateral variable area, bilateral variable area, dual bilateral variable area, stereo variable area or variable density. The advantageous processing algorithms are selected from the on screen menu and applied to the stored digital image accessed from storage system 300 for processing by the CPU or a DSP card of controller 400.

Sound track deficiencies can result from the various causes described previously. However, more specifically, dirt, debris, transverse or diagonal scratches or longitudinal cinches in a negative can produce white spots when printed. These flaws generate clicks and crackles. Such white spots tend to affect the dark areas of the track and are more noticeable during quiet passages whereas noise occurring during loud passages often originates in the clear areas of the print. Low frequency thuds or pops often result from relatively large holes or spots in a positive soundtrack formed as a consequence processing problems. Hiss can result from a grainy or slightly fogged track area. A noise envelope that follows the wanted audio signal is often caused by inter-modulation distortion.

Although the scanned audio track is represented as a continuous intensity modulated image it was advantageously recognized that sections of the image can be read from memory 300 and configured in RAM for processing using spatial image techniques. A first algorithm was developed using Matlab® to estimate the instantaneous amplitude value of the audio signal as represented by the density of the film track and digitized as a single line scan. Statistical techniques can be used to estimate the density value that truly represents the amplitude of the audio signal. First, finding the average of the density values in the line vector comprised of 2048 pixel is a good estimate of the true audio amplitude representation. This averaging process also serves to minimize the effects of unwanted noise resulting from unwanted variations in optical transmission across the track width.

Scratches across sound track can cause variations in light transmission which produce transient or impulsive noise effects such as loud pops or clicks. This form of transient noise is advantageously eliminated by a second algorithm which is applied to the line image sections of the stored exemplary 12-bit digital envelope signal. This second algorithm uses a spatial image processing technique to derive the mean values of the pixel of each image section across the width of the track.

These mean values are then used to generate the instantaneous audio amplitude of the track. The technique uses regression analysis with a weighted coefficient assigned to pixel values and their relative deviation from the mean. If a pixel has a standard deviation greater than a user set threshold, it is eliminated from the estimation process. In this way a linear approximation of the variations in density across the soundtrack width is obtained. The middle point in the data values across the line is then the mean value used to estimate the amplitude of the audio with very little effect from random noise and transient noise.

A further advantageous arrangement utilizes look up tables to provide compensation for pixel intensity values that are occur in the non-linear toe and shoulder areas of the film transfer characteristic. The look up table provides linearizing correction values for densities that extend beyond the normal linear region of the film characteristics. A computer routine maps a linear density value that corresponds to the mean amplitude values calculated with the previous methods if it falls within the non-linear range of the film. The net result is an increase in the dynamic range and signal to noise ratio of the audio signal.

During initial camera alignment the track image is observed at several film locations and if film weave is apparent the image centering can be adjusted to position the nominal center of wandering sound track path in the middle of the display image. The image size is then adjusted such that the audio track fills the width of the CCD line array. Hence it can be appreciated that as the film weaves only the horizontal position, or distribution of the end pixels vary. However, mean of the pixel intensities, which represent the audio signal amplitude, remains substantially constant because although the intensity envelope image moved it remained on the sensor array. Thus the algorithm for converting the envelope image into an audio value advantageously eliminates and corrects the effects of film weave.

FIG. 1

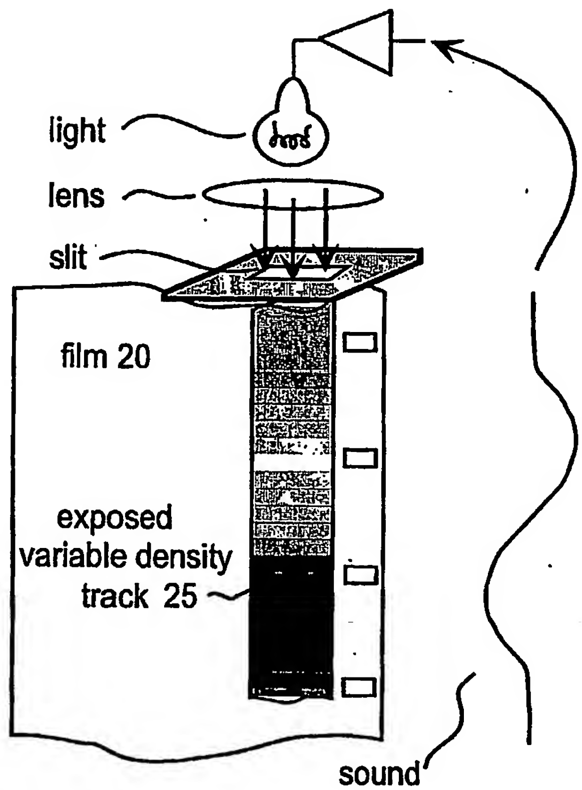

light
lens
slit
film 20
exposed
variable density
track 25
sound

FIG. 3

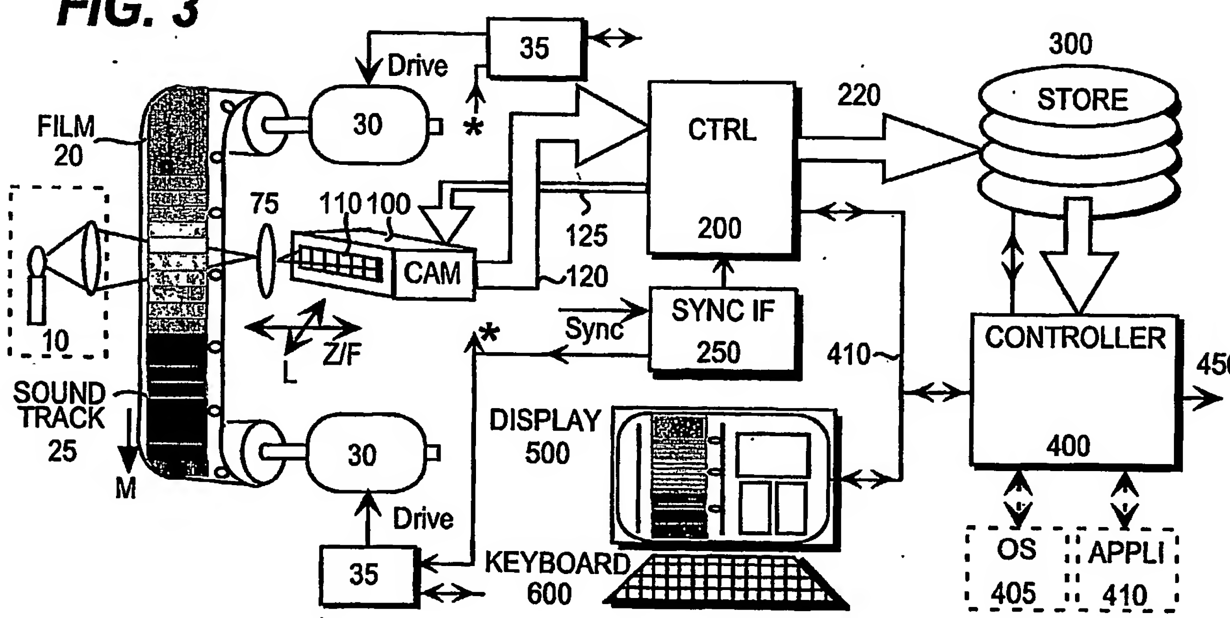
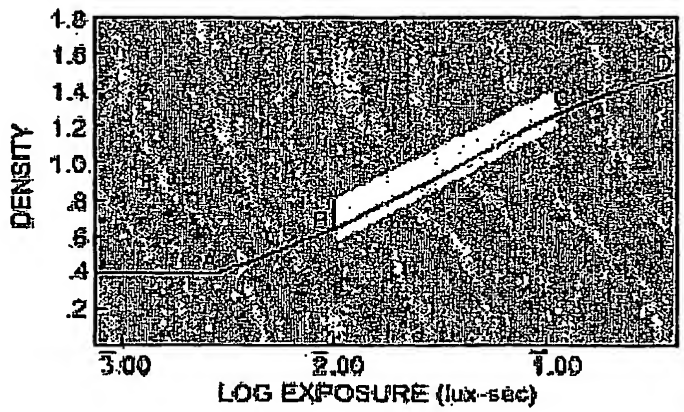
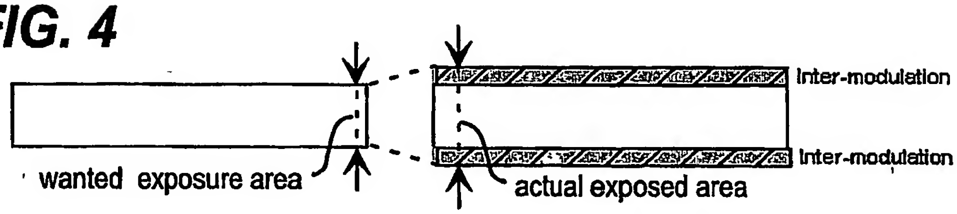

FILM
20
10
SOUND
TRACK
25
M
35
Drive
30
*
75
110
100
CAM
L
Z/F
CTRL
200
220
125
120
SYNC IF
250
Sync
*
300
STORE
CONTROLLER
400
410
450
DISPLAY
500
KEYBOARD
600
35
Drive
30
OS
405
APPLI
410

FIG. 2



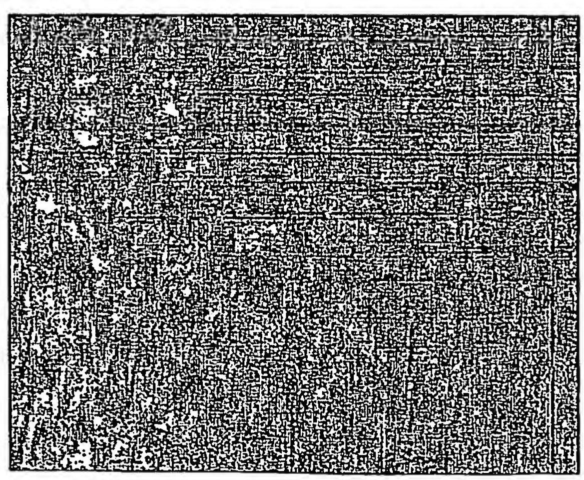
LINEAR RECORDING REGION B C

FIG. 4

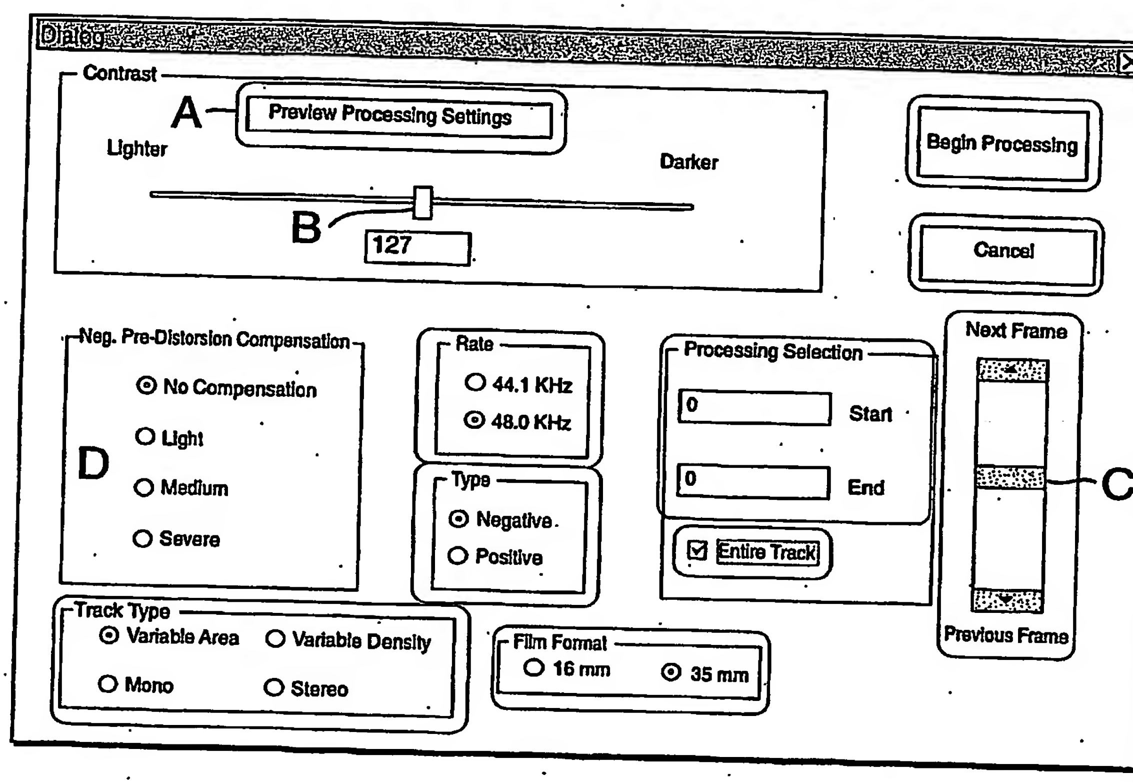


SOURCE OF INTER-MODULATION DISTORTION

FIG. 5



SCANNED IMAGE OF VARIABLE DENSITY SOUND TRACK



Dialog
Contrast
A
Preview Processing Settings
Lighter
Darker
B
127
Begin Processing
Cancel
Neg. Pre-Distorsion Compensation
No Compensation
Light
D
Medium
Severe
Rate
44.1 KHz
48.0 KHz
Type
Negative
Positive
Processing Selection
0
Start
0
End
Entire Track
Next Frame
C
Previous Frame
Track Type
Variable Area
Variable Density
Mono
Stereo
Film Format
16 mm
35 mm

FIG. 6

FIG. 7A

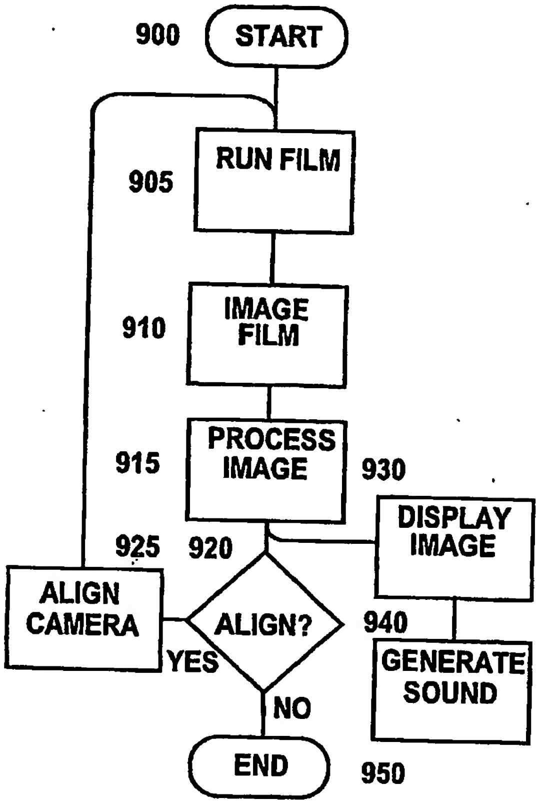


FIG. 7B

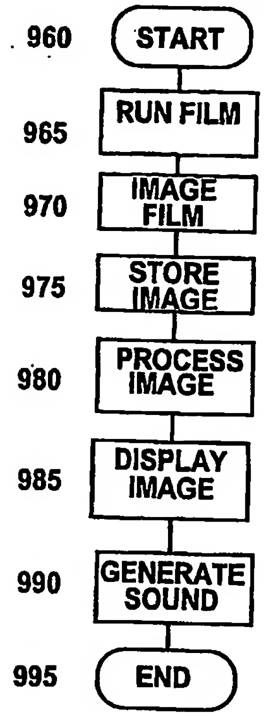


FIG. 8A

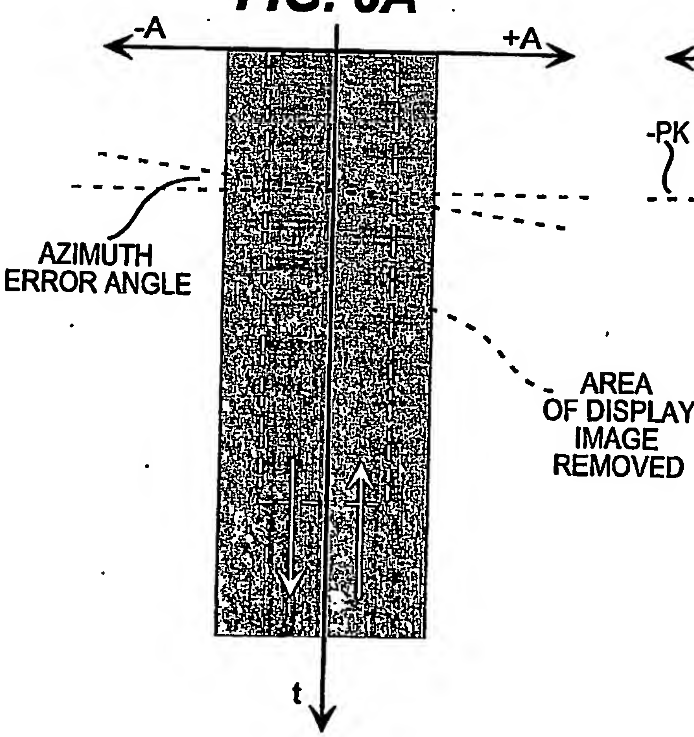
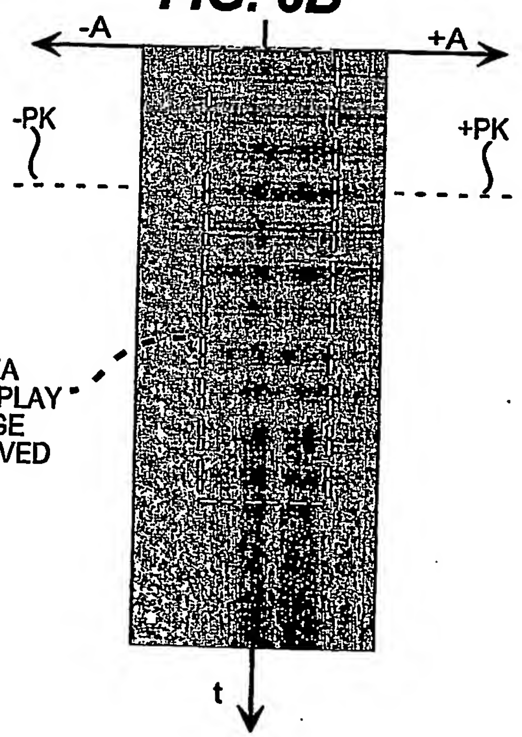


FIG. 8B



INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/005690

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G03B31/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 091 573 A (PHILIPS CORP INTELLECTUAL PTY ; KONINKL PHILIPS ELECTRONICS NV (NL)) 11 April 2001 (2001-04-11) cited in the application the whole document	1-26
X	DE 197 29 201 A (PHILIPS PATENTVERWALTUNG) 14 January 1999 (1999-01-14) cited in the application the whole document	1-8,13, 15-22

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 August 2004	25/08/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Aratari, R

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US2004/005690

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 1091573	A	11-04-2001	EP	1091573 A2	11-04-2001
DE 19729201	A	14-01-1999	DE	19729201 A1	14-01-1999